NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

USE OF AVAILABILITY BASED SPARING IN SUPPORT OF DEPLOYING U.S. MARINE CORPS UNITS

by

Janet L. Keech

December 1998

Principal Advisor:	Kevin R. Gue
Associate Advisor:	Keebom Kang

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USE OF AVAILABILITY BASED SPARING IN SUPPORT OF DEPLOYING U.S. MARINE CORPS UNITS

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ABSTRACT

The U. S. Marine Corps realizes its goal of being ready to fight in any location primarily through the Marine Expeditionary Unit (MEU). An important component of the MEU's readiness is the availability of critical equipment repair parts when they are needed. We test with three sets of past MEU data an availability based sparing model that builds repair parts blocks and show that the model outperforms the current methodology in every case.

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TABLE OF ABBREVIATIONS

AAC	Activity Address Code
ACE	Aviation Combat Element
ADTP	Administrative Delay Time, Procurement
ARG	Amphibious Ready Group
BLT	Battalion Landing Team
CEC	Combat Essentiality Code
DSU	Deployment Support Unit
EDL	Equipment Density List
FSSG	Force Service Support Group
GCE	Ground Combat Element
GenPak	Deployment Support Generator Package
HMMWV	High Mobility Multi-Wheeled Vehicle
LUBF	Loaded Unit Balance File
MAGTF	Marine Air Ground Task Force
MCO	Marine Corps Order
MEF	Marine Expeditionary Force
MEU	Marine Expeditionary Unit
MSSG	MEU Service Support Group
NEO	Non-combatant Evacuation Operation
NSN	National Stock Number
PLT	Procurement Lead Time
QPA	Quantity Per Assembly
SOC	Special Operations Capable
SMR	Source, Maintainability, and Recovery
SMU	SASSY Management Unit

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I. SUPPLY BLOCKS

"As the force that must be the most ready, when the nation is least ready, the Marine Corps must always be prepared to fight and win our nation's battles--whenever or wherever they may occur [Ref. 1]." The Marine Corps realizes its goal of being ready to fight in any location primarily through the Marine Expeditionary Unit (MEU). The Marine Corps has MEUs forward deployed at all times, ready to conduct missions ranging from full-fledged amphibious assaults to peacekeeping operations.

The MEU is a task-organized unit, consisting of a Battalion Landing Team (BLT), a MEU Service Support Group (MSSG), a composite Marine Medium Helicopter Squadron (which may also include some fixed-wing assets), and a MEU Command Element. These elements are brought together under one Commanding Officer, a concept known as an air/ground task force. The Marine Air Ground Task Force (MAGTF) concept can be used with any size unit, with the largest being the Marine Expeditionary Force (MEF). However, routine forward presence is maintained by the MEU, with units in different parts of the world at all times.

There are currently seven Marine Corps MEUs that routinely deploy across the world. They are made up of units from the first, second and third MEFs. Figure 1 shows the locations of the active MEUs.

I MEF Camp Pendleton, CA	**II MEF Camp Lejeune, NC**	**III MEF Okinawa, Japan**
11th MEU	22nd MEU	31st MEU
13th MEU	24th MEU	
15th MEU	26th MEU	

Figure 1

The MEU deploys as part of an Amphibious Ready Group (ARG). In today's environment of military downsizing, the ARG has declined from four ships to three. Thus, the space allotted to the MEU for personnel, equipment, and support items for those assets has decreased proportionally. However, despite that decrease in space, the number of missions that the MEU must be prepared to conduct has increased from 18 to

29 [Ref. 2: p.9]. Additionally, the MEU is still required to deploy with supplies sufficient to sustain itself for 15 days.

One of the primary tasks of the MSSG is to build and maintain three blocks of supply in order to support the MEU during its deployment. The first block, the organic supply block, consists of items such as cold weather clothing, tents, and individual war gear. The other two blocks are the Class IX consumables block and Class IX repairables block. The Marine Corps has all supplies divided into classes to designate types of supplies. *Class IX* refers to repair parts, with consumables being those parts that are thrown away after they have broken, and repairables being those that can be repaired and placed back into service. Both consumables and repairables support the major end items in the Marine Corps inventory. As with all aspects of the MEU, the space available for these supply blocks has decreased with the reduction of the number of ships in the ARG, and the MSSG has been forced to reduce the number of items carried in support of the MEU. For the remainder of this work, we refer to the Class IX consumables block as the supply block.

Once deployed, all elements of the MEU obtain their supplies directly from the MSSG supply block. If the supply block does not contain the necessary item, that item must be ordered from the intermediate supply activity at the base from which the MEU deployed. Delivery of these items has costs associated with it, both in dollars and in time delays. Additionally, the absence of a critical repair part will decrease the readiness of the MEU for the length of time that it takes to receive the part. For these reasons, the MSSG chooses items for the supply block that maximize the readiness (support) of the MEU while complying with the space constraints of the ARG.

A. PAST WORK

Laforteza [Ref. 3] developed a model to assist the MSSG Supply Section with the building of the Class IX supply block prior to deployment. His model was based on the concept of availability based sparing, which operates within a constraint and gives an output of parts that produce the maximum possible achieved availability within those constraints. Laforteza's model used volume as the constraint rather than the more common dollar budget, because the limiting factor for the MEU is the amount of space available on the ships of the ARG.

The MSSG currently generates the Class IX supply block using a type of demand-based sparing. This method does not operate under a constrained input, but generates expected usage based on past demand for each item. It provides a list of all parts that should be included in the block, but that list may exceed the space available to the MSSG. If it does, the MSSG Supply Section has no systematic method for deciding which parts to eliminate from the block. They are dependent on the experience of the supply and maintenance personnel who provide input on which parts are really necessary and which are not.

Laforteza's model has four required inputs. First, the total available volume must be known, because it is the constraint under which the model runs. Next, each possible item the MEU can take, its past demand, and its volume must be known. The third input is the planning horizon for the deployment in days. Finally, Laforteza introduced the concept of mission priority factors. For example, each MEU mission would be given a priority matrix for all the end items to be used in that mission. Then, the repair parts associated with those end items would be given priorities in accordance with the priorities of the end items they support. Thus, the model would favor the repair parts associated with the most critical end items depending on the missions the MEU expects to conduct.

Laforteza tested his model on the data obtained from a MEU that deployed from Camp Pendleton, CA in 1996 and 1997. His results showed that, if the MEU had used his model in developing its Class IX supply block, its backorders could have been reduced by 13 percent. This reduction could have saved approximately $11,000 in shipping costs, as well as saving the MSSG Supply Section many man-hours in developing the block [Ref. 3].

Laforteza's analysis has received much attention from units around the Marine Corps. The CG, 1st FSSG at Camp Pendleton and the Commanding Officer, 1st Supply Battalion indicated that they thought the model had potential use for the MEUs. However, despite the encouraging results of his model, Laforteza's work has not yet been implemented or tested further.

B. ISSUES TO ADDRESS

While Laforteza's work showed significant improvements over the MSSG's current methodology of building the supply block, it was only tested using data from one deployment. It does not show whether or not consistent use of the model will improve

the quality of the supply blocks taken on deployment. Additionally, Laforteza's model used the peacetime usage data of the MEF to compile its results. This is the same data that the MEUs currently use in creating their list of parts to take. Past research does not show whether the peacetime usage data is a better predictor of MEU usage than the usage data of the past deployments.

Finally, Laforteza's use of mission priority factors did not significantly affect the make-up of the supply block created by the model. In several runs of the model using different priority factors, the make-up of the repair parts included in the block remained relatively consistent. Laforteza's mission priority factors were based on the priorities of the end items as a whole, and were not mission specific. They were developed subjectively by a Marine Officer in the Force Service Support Group (FSSG) headquarters.

C. PURPOSE AND METHODOLOGY

We make three contributions in this thesis: First, in order to confirm the validity of Laforteza's results, we perform additional tests of his model using data from recently deployed MEUs. Second, we address the issue of mission priority factors and their potential use in an availability based sparing model. Third, we consider whether the MEF usage data currently used by the MSSGs to build their supply blocks is the best available predictor of MEU demand, or whether data from past deployments might be superior.

Through interviews with MEU personnel and analysis of their written operating procedures, we outline the current procedures of the MSSG in building the supply block and make a comparison of these procedures across the three Marine Corps MEFs. Chapter II summarizes these procedures and highlights differences throughout the Marine Corps. We also discuss whether or not these differences can be reconciled.

Chapter III addresses the issue of whether specific end items can be associated with particular MEU missions. We also look at mission priority factors and their relevance to the building of the supply block. We analyze whether or not those priorities are valid for all MEU missions, and whether or not the MEU can effectively predict what missions will be conducted prior to leaving on deployment. Finally, we review Marine Corps orders and directives, and report results of interviews with individuals familiar with the issue.

We conduct further tests of the validity of Laforteza's model using usage data from units of the East and West Coasts. At the same time, we analyze whether the peacetime MEF usage data is a better predictor of MEU usage than the data gathered from past deployments. Chapter IV outlines the requirements for input data in the model, specific methodologies used in obtaining the data, the shortfalls encountered in the gathering of the data, and the assumptions made in running the model.

We summarize and interpret results of the model runs in Chapter V. Our results show that the model performed better than the MEU's current method for establishing its supply block. The model was run with no user input and was strictly based on demand data that was often incomplete. Improvements in the quality of the input data as well as some input from users with past deployment experience could enhance the model's capabilities. Finally, the model takes much less time to run than the current process, and can be manipulated easily to modify results if necessary. The model could also be run using different volume constraints as in the case of a MSSG suddenly taking a space reduction for the supply block. The users (MSSG supply personnel) were favorably impressed by the model's ease of use and interested in its application to making the block-building process easier and less time consuming.

II. BLOCK BUILDING PROCEDURES

The Class IX supply block is built by the MSSG Supply Section with a great deal of input from maintenance personnel within the MSSG. The supply section consists of approximately 15-20 Marines, with a Company-grade (O-1 to O-3) Supply Officer in charge. This officer (and most of his Marines) will go on one or two deployments, and then be rotated to another job. Often, there is little to no formal turnover between the Supply Officers when they change hands. Therefore, the supply section will "reinvent the wheel" regularly when building the block, a process that is very similar from deployment to deployment.

While the procedures are generally the same across the Marine Corps, each MEF uses slightly different data and criteria to produce a finished product. Additionally, there are some differences between MSSGs of the same MEF, depending on the past experiences and data preferences of the supply and maintenance personnel.

A. ESTABLISHING THE EQUIPMENT DENSITY LIST

The process begins by establishing the Equipment Density List (EDL), which contains all the major end items that the Ground Combat Element (GCE), MSSG, and MEU headquarters will take with them on deployment. The Aviation Combat Element (ACE) equipment is not included in the EDL, nor is the MSSG responsible for stocking Class IX repair parts for the ACE. The EDL is developed by high-level planners of the MEU, and takes into account the current threat situation, and the likely missions that the MEU will conduct. Despite that up-to-date planning, the EDL does not change significantly from one deployment to the next. The EDL is scheduled to be established approximately six months prior to the deployment, but is often not finalized until much later than that. For example, one recent deployment did not finalize its EDL until four and one-half months prior to deployment [Ref. 4]. Another Supply Officer had to proceed with building the block using an incomplete EDL. The remaining steps in the process were filled with inaccurate data and assumptions, causing the block to be revised extensively later in the process [Ref.5].

With minor exceptions, the EDL is fairly consistent from year to year for a certain MEU. One common EDL difference is a result of the MEU Commanding Officer's decision regarding whether or not to deploy with tanks. For example, in the past, the 13th

MEU has usually deployed with tanks, while the other two I MEF MEUs have not. However, the current 11th MEU Commanding Officer changed this trend by deciding to deploy with tanks [Ref. 6].

B. DEPLOYMENT SUPPORT GENERATOR PACKAGE

After the EDL is complete, it is sent to the MEF intermediate supply activity (SMU).[1] The SMU runs a program called the Deployment Support Generator Package (GenPak), which uses MEF usage data, the length of support requested (either 15 or 30 days), and the EDL quantities to create a recommended quantity for the MEU. The GenPak uses twelve months of MEF peacetime usage data to compute the recommended quantities. The GenPaks for the MEFs differ slightly in their appearance and in the calculations used for determining recommended MEU quantities, but they all use the same basic theory and types of data.

The GenPak is designed to list all consumable repair parts associated with the end items submitted by the MSSG. The output provides the Supply Officer with the total past year's demand for each of those repair parts, along with an average monthly recurring demand. The association between the end item and the repair part is managed by Marine Corps Logistics Base, Albany, in an Application Data Program. Because this data is not often updated, there are many repair parts for which no association has been made to an end item [Ref. 7]. Additionally, the GenPak does not account for common items. For example, if a certain filter is used for both a 5-ton truck and a tank, the GenPak only takes into account the TOTAL demand for that filter, or the demand for both the 5-ton and the tank. It does not consider the fact that the MEU may be deploying with only 5-ton trucks and no tanks [Ref. 8].

The MSSG Supply Officer has some flexibility in what will be included in his GenPak. For example, the program uses a minimum number of hits (requisitions) as criteria for an item to be included in the output. That number is flexible, and is usually set at ten per year. If the Supply Officer wants to see a recommended MEU quantity for every item, regardless of the number of peacetime hits, he can request that the GenPak show any hits greater than zero [Ref. 8].

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[1] At II MEF, located at Camp Lejeune, NC, the intermediate supply activity is called Intermediate Supply Support Activity (ISSA). I MEF and III MEF call this activity the Sassy Management Unit (SMU).

Additionally, the MSSG Supply Officer has a choice of what Combat Essentiality Codes (CEC) the GenPak will include. Each end item and repair part is given a CEC, which is based on that item's ability to degrade the mission of the unit (a complete listing of CECs is at Appendix A [Ref. 3:p. 55]). For the most part, the GenPak is made up of CEC 5 and 6 items, which represent combat essential parts and mission essential parts. Additionally, some CEC 3 (safety related items) may be included if there is space available. Supply and maintenance personnel do not give the CEC codes. The system is not always accurate, and may have a critical alternator listed as a CEC 6, but have the bracket that is necessary to hold that alternator in place with a non-mission critical code assigned to it [Ref. 9]. For this reason, the GenPak is often little used and the block is built primarily through the past experience of the supply and maintenance personnel [Ref. 4]. Another problem with the recommended quantities of the GenPak is that the peacetime usage data may differ significantly from that of the deploying units, as they are doing more training and exercises to ready themselves before and during deployments.

The I MEF SMU recently hired a contractor to create a program that will categorize items by the priority at which they are ordered. For example, the repair shop would order both the above-mentioned alternator and its corresponding bracket at a high priority, regardless of the CEC assigned to each of the parts. This priority may reflect more accurate criticality than the assigned CEC currently reflects. A comparison of the existing CEC codes and the results of their actual priority in ordering may be useful in determining the validity of the CEC codes.

A final shortfall of the GenPak is that it does not accurately account for the difference in quantities of end items between the MEU and the entire MEF. This is an area in which the I MEF and II MEF GenPaks differ slightly. The II MEF version accounts for the size of the units being supported by multiplying the average monthly recurring demand quantity by one-tenth. This quantity is believed to be the average ratio between MEU demand and MEF demand [Ref. 10]. The II MEF GenPak also lists each repair part differently for every end item it supports. This allows the supply and maintenance personnel to analyze parts for the end items separately.

The I MEF GenPak currently does not calculate a ratio between MEU end item quantities and MEF end item quantities. It provides the Supply Officer with the average monthly recurring demand for the MEF, and leaves it to the supply and maintenance

personnel to reduce that number according to their quantity of end items.[2] Additionally, the I MEF GenPak only lists each end item one time, and multiplies the demand for that item by the number of end items on the EDL the item supports [Ref. 11]. Excerpts from I MEF and II MEF GenPaks are included at Appendix B.

Both I MEF and II MEF use the GenPak as a starting point for building their supply blocks, but supply officers from both locations agree that they do not use the GenPak to a high degree. The majority of the parts to be included in the block are determined by the maintenance personnel of the MSSG and BLT. These individuals base their input and changes on past experience (both garrison and deployed), using the GenPak primarily as a guideline for the parts to be considered.

Units of II MEF (Camp Lejeune) add an additional step to the process. After maintenance personnel make recommendations to changes in the GenPak, those recommendations are compared to a "three-MEU usage report." This report lists an average MEU usage by National Stock Number (NSN). The report usually covers 12 months, but usage data is held for a total of 27 months [Ref. 12]. However, this MEU usage report only captures data on items that were actually filled from the original supply block. It does not account for items that were backordered to the SMU.

III MEF units (Okinawa, Japan) also begin with the running of the GenPak, but their procedures differ significantly after that step. The next step after the GenPak is produced is to compare the NSNs listed by the GenPak to an ABC Report, or Sales Matrix. This report evaluates the number of hits an NSN has had over 12 months, and divides the NSN into three categories of A, B, and C. The "A" category is made up of those items with greater than 50 SMU reorders annually and represents approximately 20% of the demand. The "B" category contains those items with between 10 and 49 SMU reorders per year and represents about 40% of the total demand. Finally, the "C" category consists of those items with less than ten SMU reorders annually. The "C" category items are not included in the initial block unless an exception is made for new parts that do not have adequate usage recorded due to time [Ref. 13].

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[2] In the past, a GenPak was used by I MEF that calculated a ratio of MEU end item quantities to MEF end item quantities and adjusted the recommended MEU demand quantities based on that ratio. The program was PC-based, developed locally at Camp Pendleton. Since the developer of that program was transferred, 1st Supply Battalion has been unable to continue running that program [Ref. 7].

C. PHYSICAL BUILDING OF THE BLOCK

After the GenPak has been "scrubbed" by the supply and maintenance personnel, it is returned to the SMU. The General Account section of the SMU issues the parts requested by the MEU that are on hand and orders the remaining parts requested. The parts are received by the MSSG and stored until the MEU deploys.

The MSSG does not always turn in the Class IX block when it returns from deployment. Often, they will store the parts in their own warehouse until they determine what items will be needed for the next deployment. Then, they will turn in only those items that will not be part of the next block. However, the SMU may require the MSSG to turn in some items that are needed for another MSSG that will be deploying in the near future, or for MEF units operating in garrison.

Once the MSSG Supply Officer is provided with the amount of space on the ship allocated to the supply block, he fits the block into the appropriate number of quadcons and palcons.[3] In general, the amount of space allotted to the Class IX block is fairly consistent from one MEU's deployment to the next. As one supply officer stated, "Everything is carried in the same number of containers every year. So I just adjust to fit everything in those containers [Ref. 14]."

However, the space on board ship devoted to the Class IX block will occasionally be cut, and the supply officer must cut down the supply block to match the space available. MSSG-13 is currently preparing to deploy from Camp Pendleton, CA. The space available to them was cut considerably from what they had expected. When this happens, the block is cut in one of two ways. Some units may simply reduce each NSN by the same percentage. For example, if the space available was reduced by 25%, each NSN quantity would be reduced by 25% as well [Ref. 3:p. 16]. However, this is not common practice and it does not produce good results. A more common reduction technique is for the Supply Section to go back to the MEU maintenance personnel and start over again. Each line item of the initial block is reviewed, with the least critical ones being removed from the block until the space constraints are met. Once again, this is a very laborious process based on the experience of the personnel involved [Ref.5].

[3] Quadcons and palcons are standard containers used by the military to store smaller items. Each has drawers and compartments suitable for storing a large number of items separately.

D. SUPPORT PROCEDURES WHILE DEPLOYED

Once the MEU is deployed, all requisitions from the BLT, MSSG, and MEU headquarters are sent to the MSSG supply section. If the MSSG can fill the demand from the supply block, that is what is done and it is recorded as usage. If the item cannot be filled from the block, procedures differ for units of I MEF and II MEF:

1. I MEF Procedures

The deployed units of I MEF operate with all requisitions going through the MSSG Supply Section, whether they can be filled by the initial Class IX Supply Block or not. For example, if the BLT needs a filter, they prepare a requisition and submit it to the MSSG Supply Officer. The block is checked to determine whether the order can be filled. If the part is not available, the MSSG backorders the request to the Deployment Support Unit (DSU) of the SMU. The DSU only processes requisitions coming from the MSSG. If the BLT sends a request directly to the DSU, it is not processed [Ref. 5]. When DSU obtains the requested part, they send to the MSSG, who then transfers it to the BLT.

2. II MEF Procedures

The deployed units of the East Coast operate somewhat differently than those of I MEF. All requisitions from the BLT, MSSG, and MEU headquarters are still sent to the MSSG Supply Section. There, they are screened to determine whether or not that request can be filled from the Class IX Supply Block. If the requisition is filled, it is recorded as usage on the MSSG account. However, if the item requested is not available in the Class IX Block, the MSSG will forward the requisition to DSU under the using unit's own document number.

E. CAPTURE OF USAGE DATA

While the deployment procedures are different between the two MEFs, both supply systems capture usage data in the same way. Even though the I MEF MSSG is managing the backorders for the BLT and MEU HQ, the usage for those backorders is captured under the Activity Address Code (AAC) for the supported units rather than that of the MSSG. For this reason, the complete usage for the MEU can only be captured by

pulling from the system the usage for all three AACs: the MSSG, the BLT, and the MEU HQ.

F. RECONCILIATION OF PROCEDURES

The differences in the procedures outlined above are not significant between the three MEFs. While each "coast" may have slightly different methods for building the block and different headings on its GenPak, the information they are getting to build their blocks is essentially the same. Both MEFs are receiving one year of MEF usage data that is the basis for a 30-day MEU requirement estimate. Even though the MEUs are only required to deploy with 15 days of sustainment per Marine Corps Order, they will usually err on the safe side and use a 30 day demand estimate when stocking their blocks [Ref. 11]. Neither MEF relies heavily on this data, but Supply Officers prefer to rely on the experience of their maintenance personnel and their own past experience.

While deployment procedures appear to be different in that the MSSG manages backorders in I MEF and the using units manage their own backorders in II MEF, the usage data captured is the same. The only significant difference in the deployment procedures is that the MSSG in I MEF has many more requisitions to manage than that of II MEF. However, I MEF is co-locating the MSSG, BLT, and MEU supply sections on board ship now in order to better spread the workload for backorders.

III. MISSIONS AND MISSION PRIORITY

Never, ever does it go how we planned [Ref. 15].

A. MEU(SOC) MISSIONS

In order for a MEU to be Special Operations Capable (SOC), it must be proficient at conducting all MEU(SOC) missions. The number of MEU(SOC) missions has increased in the past several years from 18 to 29, although many of the 29 missions have some degree of overlap. These missions vary in scope from a full-scale amphibious assault to peacekeeping operations. A complete list of MEU(SOC) missions is at Appendix C [Ref. 2:p. 9].

Prior to the establishment of the EDL, the MEU(SOC) commander and his staff analyze the upcoming deployment, both for scheduled operations as well as possible additional missions. Marine Corps Order (MCO) 3120.9A, Policy for Marine Expeditionary Unit (Special Operations Capable), provides the commander with a basic equipment loadout. The commander may adjust this loadout based on his estimate of the situation [Ref. 2:p. 14].

The MEU(SOC) commander, however, must be careful to not degrade his command's ability to conduct all MEU(SOC) missions. As stated by Marine Corps Order,

> The MEU(SOC) is organized, trained, and equipped as a self-sustaining, general-purpose expeditionary force that possesses the capability to conduct a wide spectrum of conventional and selected maritime special operations, rather than a force which is tailored for a specific operation or area of responsibility [Ref. 2:p. 9].

B. MISSION PRIORITY FACTORS

There are two types of mission priority factors that we considered for implementation in determining the best supply block for the MEU. The first looks at assigning each end item an overall priority for the deployment, without taking into account specific missions and that item's role in those missions. Repair parts would then be prioritized according to the priority of the end item they supported.

The second method is to prioritize individual end items for each specific mission. Then, repair parts would be prioritized based on the relative probability of conducting certain missions and their associated end items' priorities for those missions.

1. Overall End Item Priority

In his thesis, Laforteza assigned each end item a priority from A to D, based on the input of a staff officer in the 1st Force Service Support Group Plans section. The priorities were based on a generic MEU(SOC) mission. When the priorities of the end items were transferred to their respective repair parts, the repair part was given the same priority as the highest end item it supported. This resulted in 80% of the repair parts being given a mission priority of A [Ref. 3:p. 32].

Despite the large percentage of priority A repair parts, the overall end item priority method has credibility. One officer we interviewed conducts the certification training for MEU(SOC)s prior to their deployment. He stated that you can identify the MEU(SOC) unit's prioritized equipment by looking at the end items that are pre-loaded on the landing craft aboard the ships. Generally, these items include light armored vehicles, tanks, HMMWVs (high mobility multi-wheeled vehicle) that contain heavy machine guns and other weapons systems, and some trailers for storage of additional equipment [Ref. 6]. However, the same officer indicated that it is difficult to give a lower priority to any end item in today's MEU(SOC) because the shift from four to three ships in the ARG has greatly reduced the total number of end items taken.

When Laforteza used these priority factors in the running of his model, they did not affect the repair parts the model recommended for the supply block. Because so many of the repair parts had a priority of A, the differentiation between the priority factors was negligible.

2. Assigning Mission-Specific Priorities to End Items

The second alternative in assigning priorities to end items is to give each a different priority for every potential MEU(SOC) mission. The difficulty in this method is the variability in missions. Two executions of the same general mission type may look completely different and use different numbers and types of end items. To generalize and say that a Non-combatant Evacuation Operation (NEO) mission will always use certain end items is nearly impossible because the NEO parameters change based on political,

geographical, and other factors. For example, the 1990 NEO in Liberia, Africa was of a very small scale with very little equipment involved. However, a variety of planning scenarios had been developed for that same NEO with wide ranges of end items being used. The decision on what equipment would actually be used was not made until just prior to execution of the operation [Ref. 16].

The timing of an unexpected mission can also greatly affect the end items used. For example, an operation could occur during or just after a planned exercise. Equipment may be loaded on the ships differently than the initial load-plan and some end items may not be available for use simply due to their location on ship [Ref. 6].

Another factor in assigning mission priorities is the subjectivity of such an assignment. A commander's past experience and his familiarity with the capabilities of certain end items will likely sway his preferences of which end items to use in an operation.

Finally, as the opening quote suggests, it is difficult for the MEU(SOC)s to plan long-term with enough certainty to base sparing levels on that planning. Even if a MEU is certain to be conducting a large-scale humanitarian assistance mission, most commanders would resist degrading the capability of their combat equipment in order to better support the generators and 5-ton trucks associated with that mission.

For all of these reasons, we chose not to include any type of mission priority factors in our validation of Laforteza's model for this work.

IV. METHODOLOGY AND DATA ISSUES

Laforteza's work stated that an availability based sparing model could be used by the MEU(SOC) to create a supply block that reduced backorders during the deployment. Additionally, he stated that labor-hours and shipping costs could be reduced. We test the validity of Laforteza's model in two ways: (1) conducting backtests of recently deployed units to validate the positive results of Laforteza's test and (2) taking the model to a unit preparing for deployment to analyze the model from a user's perspective.

A. DATA REQUIREMENTS

While Laforteza's work used an availability based sparing model developed specifically for his use, commercially available products have been developed to serve a similar purpose. For our validation, we used the commercial product VMETRIC, a multi-echelon, multi-indenture stock optimizing model produced by Systems Exchange in Pacific Grove, CA.[4] VMETRIC is designed to perform two primary tasks: (1) For a specified availability or fill rate, VMETRIC finds the least costly mix and geographic distribution of stock and (2) Within a specified budget constraint, VMETRIC finds the mix and geographic distribution of stock that maximizes the availability and fill rates [Ref. 17:p. 2].

VMETRIC was primarily designed to provide optimal spare parts levels for one system at a time. For example, it might optimize all the parts necessary to maximize a 747 jet airplane's operational availability within a certain cost constraint. Factors such as reparability of the item, level of repair required for each item, delay times associated with both procurement and repair, whether or not there will be lateral resupply between operating sites, and the desirability of cannibalization of equipment all may be taken into account in the VMETRIC model.

[4] Multi-echelon refers to the program's ability to allow maintenance to occur on items at different levels, which are generally organizational, intermediate, and depot. Multi-indenture means that parts have different hierarchy in the composition of the system. For example, a belt that is part of an alternator would be of a lower indenture than the alternator itself.

The MEU(SOC) problem is different from the problem VMETRIC is designed to solve. We are asking the program to optimize spare parts across many systems of different types rather than optimizing a mix of spares associated with one end item. For our purposes, the MEU was considered a single end item, with all the repair parts in support of it. Rather than stocking to some availability level, we use the model simply to maximize fill rate from the block given space constraints.

The Marine Corps does not keep detailed indenture data for repair parts, so we gave every repair part an indenture code of one in VMETRIC. This means that, although a tire will go directly on a truck and a screw may be used on an alternator which would then be used on the truck, both the tire and the screw are given the same indenture (or relationship) to that truck.

VMETRIC is designed to accept thirty-six input values, which are listed in Appendix D [Ref. 17] . Many of these values are not relevant for the MEU problem. For example, because we studied the consumable supply block, we did not use repair cycle time data or repair in place rate. We considered the MEU one site, which eliminated the need for lateral resupply data between sites. For the purposes of this study, we concentrated on obtaining the following information to run V-Metric:

1. Volume

The volume of the item was used in lieu of the item price input and a "shadow price" was constructed for the cost constraint in building the block. VMETRIC allows the user to give weights to the price, volume, and weight of the items in order to calculate a shadow price. Because volume is the primary constraint for MEU(SOC) units, we assigned a weight of one to volume, and a weight of zero to price and weight. Thus, the model only considered volume when it stocked the repair parts.

Each item entered in the model must be given a positive volume. The program is only designed to take input values to two decimal places (1/100 ft^3). Because many of the items comprising the supply block are small, such as nuts, screws, and bolts, they had volumes considerably less than 0.01 cubic feet. However, a volume of 0.00 was not acceptable to the program, so those items' volumes were rounded up to 0.01 cubic feet for the purpose of this study.

Additionally, volumes of many items were not available. Laforteza's work identified 4,910 items for which he assumed a volume of .01 cubic feet. This value was

the median of the known volumes of the NSNs in his study (a total of 19,100 NSNs) [Ref. 3:p. 31]. We conducted further research to find the unknown volumes during the course of our study. Storage personnel at I MEF maintain a database of volumes that they obtained by using a machine called the Cubiscan. However, this database only produced 66 of the unknown volumes. The Defense Logistics Services Center compiles a CD-ROM series called FedLog that includes pertinent information about individual NSNs, but does not include volume measurements [Ref. 18]. Therefore, for the purposes of this study, we continued Laforteza's assumption that the missing volumes were equal to 0.01 cubic feet.

We do not believe either of these assumptions will affect the results of the model tests, because the same assumed volumes were used for computing both the space actually used by the MEU and the space given to the model as a constraint. For example, when we were given a list of the items taken by the MEU on deployment, we calculated the total space those items used on board ship. Then, we used that total space as a constraint within which the model must stock its parts. Because we used the assumed volumes in both the calculation of the total space and in the running of the model, the assumptions favor neither one.

Of course, the assumptions could be meaningful when actually building a block, depending on how much the true size of the items differs from the assumed volume. Most of the items in the consumables supply block are very small, with only 6% of the items with known volume having a volume of greater than 1.0 cubic feet. However, these items account for over 80% of the total volume of the block. Therefore, the assumption of .01 cubic feet for large items could greatly underestimate the actual total size of the block.

2. Demand

The demand field in VMETRIC requires the number of demands per million operating hours of equipment. There are two problems associated with this field. First, the repair parts the MEU uses often support several end items, which may have different levels of operating hours. The supply system keeps a total demand figure for all the repair parts, but does not break down that demand among the end items the part supports. Therefore, we cannot know how many operating hours are represented by the demand figure given by the GenPak.

Second, the Marine Corps supply system does not maintain demand data per operating hours of equipment. Instead, it records demand over a certain period of time, regardless of use of equipment. The GenPak uses annual demand figures to provide the MSSG with an expected demand for a part for 30 days. Those calculations are performed in a slightly different manner for I MEF and II MEF, but each MEF's GenPak has a column representing the estimated MEU demand for one month. A more complete discussion of existing Marine Corps data and its applicability to availability based sparing can be found in Penrose [Ref. 19].

For this field, therefore, we began with the GenPak recommended quantity for monthly MEU usage. However, because VMETRIC is looking for data per million operating hours, we converted the GenPak's monthly demand prediction using a worst-case figure of 168 hours/week, or 24 hours/day usage on equipment. We multiplied the GenPak recommended MEU stockage quantity by 1488 hours to represent a total of one million hours of usage.

3. Other Fields

The NSN and part name identify the part. All parts we considered for stockage in the supply block were required to have a unique NSN. If available, the part name was included for easy identification.

Quantity per assembly (QPA) is a required field for running VMETRIC. We used a QPA of one for every NSN, which means that the entire MEU is treated as one end item, with all the repair parts as second indenture level items beneath it.

We used the on-hand quantity for the General Account (representing the SMU's on-hand quantities) as the maximum stock field. We assumed that the SMU could not provide the MEU(SOC) with a greater quantity than they currently had on hand. Currently, if the MSSG wants more than the SMU's on-hand quantity, they submit a backorder for that part and it is shipped to them when it comes in. However, they often do not receive the part prior to their departure and the backorder remains with them while on deployment. Because those items would not be included in the initial supply block, we did not include them in our model's options for building an initial supply block.

We took the procurement lead time (PLT) and administrative delay time, procurement (ADTP) from the data of II MEF. Based on the experience of the 26th MEU, we assigned a PLT of 38 days and an ADTP of 7 days. To ensure that this estimation

would not affect the model results, we also ran the model with a worst-case combined PLT and ADTP of 180 days. The results did not differ significantly from those we observed with the total delay of 45 days. We believe that the change from 45 days to 180 days did not affect the outcome of the model because the same delay time was used for every item, making it impossible for the model to distinguish between items based on delay time.

Finally, we assigned the Source, Maintainability, and Recovery (SMR) code of PAOOZ for all consumable parts. This code can be broken down into the following:

- PA: The item is procured and stocked for anticipated or known usage.
- O: The support item is removed, replaced, and used at the organizational level of maintenance
- O: The lowest maintenance level capable of complete repair of the support item is the organizational level.
- Z: Non reparable item. When unserviceable, condemn and dispose at the level indicated. [Ref. 20]

B. DATA OBTAINED FROM MARINE CORPS UNITS

Data for our analysis was obtained from the two most recently completed deployments, 11th MEU from I MEF and 26th MEU from II MEF. These units had the most complete and recent data available to us and were not deployed at the time of the study. Because the MEUs do not routinely keep the data we were seeking, the MEUs that had deployed earlier did not have that data.

We gathered four items of data: The first item, the Loaded Unit Balance File (LUBF), is a list of what the MEU took with them when they left on deployment. This data is necessary for computing the total volume that the MEU used for its supply block and for comparison purposes after running the model. The second data requirement is the GenPak based on the MEU's EDL. This represents the usage data for the entire MEF over a 12-month period, with a recommended MEU usage quantity. The GenPak also provided us with the Combat Essentiality Codes, the Maximum Stock Levels, and the NSN's and nomenclatures of the items. Third, we obtained the usage data from past MEU(SOC) deployments. We used this data for alternative usage quantities to compare the effectiveness of past MEU data and peacetime MEF data in predicting the usage of an

upcoming deployment. Finally, the actual usage for the unit being studied was necessary to judge the success of the model as compared to the LUBF.

1. 11th MEU (I MEF)

The 11th MEU did not keep a copy of their pre-deployment LUBF. The LUBF is updated every week and units are not required to hold previous copies of the LUBF once they receive a more recent copy. We interviewed several MSSG Supply Officers from I MEF, but none of them had been given an example of a pre-deployment LUBF when they replaced the outgoing Supply Officer.

There are no specific criteria given to MSSG Supply Officers constraining the number of NSNs in their supply block. The I MEF Supply Blocks are generally between 3,000 and 5,000 NSNs. However, the SMU does not allow the MEU to take any item for which the MEF does not have a requisitioning objective. The philosophy is that if the MEF has not had enough usage on a part to justify a requisitioning objective, then the MEU should not be expecting to record usage on that part. Secondly, the SMU discourages the MEU from stocking a greater quantity of an NSN than the recorded usage of the MEF for a similar period of time [Ref. 21].

For this study, we obtained a LUBF from 11th MEU that represented the NSNs that the MEU had on hand when they returned from deployment vice those they took with them when they left. The difference in the LUBFs is primarily in NSNs that were depleted and not replenished through reorder points near the end of the deployment cycle, because the MEU will no longer be replenished automatically after a certain point in time [Ref. 22].

Additionally, when the MEU returned, it was required to turn in approximately 300 NSNs to the SMU to be issued to other units that needed the parts prior to 11th MEU's next deployment [Ref. 22]. The MEU had taken out approximately 5,000 NSNs when it left on deployment, and the most complete LUBF we could obtain had 4,483 of those NSNs remaining on it.

We expect these differences to affect the results in favor of our model, because the NSNs returned to the SMU are high demand items that the SMU did not have on hand to issue to units that needed them. The 11th MEU LUBF we used for this study will understate the NSNs and quantities that the MEU had on hand for these important items,

as well as those items that the MEU depleted during the deployment and did not replenish.

We ran the model on this data despite these problems, knowing that the only conclusive result would be one in which the LUBF performed better than the model with such a great handicap.

The GenPak we received from the SMU Operations Section was based on today's usage data vice that of the time that 11th MEU was preparing to deploy. The past MEF usage data is no longer available because each quarter the oldest quarter usage is purged as the most recent data is saved. We do not believe the use of today's usage data significantly affects the results of our backtest, because the data still represents a full year of usage, with all seasons represented. The type of equipment has not changed significantly from the time of the 11th MEU deployment to the present. The GenPak provided all usage for any CEC 5 or 6 repair part associated with the end items that 11th MEU took with them. The GenPak included any item that had greater than zero hits for the past year (i.e., registered any demand in the past year). The SMU provided a GenPak that contained 5,684 unique NSNs.

We were unable to obtain past MEU(SOC) usage data from I MEF. We were given 27 months of usage data that we were told represented total MEU usage, but later found out that it only represented the usage of the MSSG and the BLT and MEU Headquarters items that were filled directly from the supply block. It did not include any items for the BLT and MEU Headquarters that were backordered to the SMU [Ref. 7]. Therefore, we did not compare MEF usage data and past MEU usage data for I MEF units.

We obtained 11th MEU usage data from two sources at I MEF. The first set was from the Maintenance Records at I MEF. The maintenance data should parallel the supply data because the two systems interact. However, sometimes records are not reconciled properly and the information will not pass from one system to the next [Ref. 7]. This set of 11th MEU usage data consisted of 570 NSNs, of which 363 were CEC 5 or 6 items.

To verify the Maintenance Records data, we also pulled 11th MEU usage data from the SMU through the supply records. This set of data was drastically different than the data from the maintenance records. In the supply usage data, there were a total of 2,181 NSNs, of which 966 were known to be CEC 5 and 6. See Penrose [Ref. 19] for a discussion of this type of discrepancy.

For our study, we used the supply data, because the number of NSNs was more in accordance with what we expected a MEU to use on deployment.

2. 26th MEU (II MEF)

The Supply Officer from the 26th MEU provided a copy of the pre-deployment LUBF, which consisted of 2,172 NSNs, of which 943 were classified CEC 5 or 6. This is less than half of the number of NSNs taken by 11th MEU, but the total volume of the two supply blocks is nearly equal.

As with I MEF, the Supply Officers of II MEF are not limited to a certain number of NSNs for their supply blocks. However, the II MEF SMU encourages the MEU to aim for deploying with the smallest number of NSNs possible. The MSSG 26 Supply Officer stated that, while he was building his supply block, the SMU OIC told him that he should strive to create a block smaller than the one that was deployed at the time [Ref. 23]. II MEF has this policy to minimize the "comfort factor," or unnecessary parts, that the MSSG takes with them on deployment [Ref. 25].

The GenPak for the 26th MEU EDL contained all CEC 5 and 6 items with greater than zero hits for the previous year. It was also based on current usage data vice the usage at the time of the 26th MEU's deployment. The total number of unique NSNs included on this GenPak was 1,062.

The II MEF GenPak had less than one-fifth the number of NSNs provided by the I MEF GenPak, despite being based on similar equipment density lists. The primary reason for the difference is the way the GenPak programs are written. The II MEF GenPak reduces the monthly MEF demand by one-tenth in order to account for the smaller size of the MEU as compared to the entire MEF. When that calculation is done, the program rounds the fractions and rejects all recommended MEU stockage quantities less than one [Ref. 24]. The II MEF SMU eliminates these NSNs completely from the GenPak report to discourage the MEU from stocking more NSNs.

The II MEF SMU Operations section collects the same usage data as the units of I MEF. They do not compile total MEU(SOC) usage, but keep records of the MSSG usage and that of items taken from the supply block. We were unable to get total usage from past MEU(SOC) units.

We did find a database compiled by a staff officer of the 2nd FSSG containing all CEC 5 and 6 items from the past six MEU(SOC) deployments that had an average of four

or more hits over the seven months prior to deployment and the six-month deployment (a total of 13 months) [Ref. 25]. The usage data for this database was obtained through the maintenance system vice the supply system. We obtained a copy of that database, which had a total of 751 unique NSNs, for use in comparing past MEU usage data to MEF usage data.

The II MEF SMU Operations section compiled the actual usage data from the 26th MEU by compiling the three Activity Address Codes of the BLT, the MEU Headquarters, and the MSSG and consolidating the results. There were a total of 7,969 unique NSNs used by the 26th MEU, with 2,401 of them categorized as CEC 5 and 6. This number is much higher than we expected and does not match the MSSG 26 Supply Officer's estimation of the number of NSNs used.

We suspect that the data may contain usage from a longer period of time than the MEU's six-month deployment. For example, the usage may represent an entire year's data rather than a six month period. This would cause the number of backorders shown by both the model and the LUBF to be overstated.

While this misrepresentation will not affect the total backorders in favor of either the model or the LUBF, it will have an impact on the percentage difference in backorders for whichever method performs better. Figure 2 shows this effect with a hypothetical example. While the number of backorders increases by the same amount with the greater usage, the percentage change in backorders is smaller when the demand is greater. Therefore, if the usage data we received is greater than the actual usage recorded by the 26th MEU, the percentage difference between the model and the LUBF quantities will be understated.

	LUBF	MODEL	PERCENT DIFF
On Hand Quantity	100	50	
Backorders with Usage of 150	50	100	50%
Backorders with Usage of 1500	1400	1450	3%

Figure 2

C. ASSUMPTIONS USED IN RUNNING THE MODEL

We made the following assumptions when running the model:

1. All unknown volumes were assumed to be .01, based on Laforteza's research. As discussed previously, this assumption affects the performance of the LUBF and the model stockage quantities in the same way.

2. We ran the model using CEC 5 and 6 items, and assumed that success or failure with these items translated to success or failure on a larger scale with all CEC items.

CEC 5 and 6 items are those most critical to mission accomplishment. The success of the model in building a supply block that performs better than the current methods with these items alone would be a benefit to the MSSG Supply Officer. However, stockage of the lower CEC repair parts is accomplished in the same way as that of CEC 5 and 6. The GenPak can be produced for all CEC items for input into the model. Therefore, the model should work in the same manner for lower CEC items as it does for CEC 5 and 6.

If the model were used in this manner, it could be done in one of three ways. First, if the model is run for all CEC items, a higher criticality should be given to the CEC 5 and 6 items because their availability can cause a greater impact to the readiness of the MEU. Second, the volume constraint for the model can be divided into two parts, one for CEC 5 and 6 items and a second one for all other CECs. Then, the model could be run separately for each category and the results consolidated for the entire block. Third, the model could simply be run for all CECs, with the total volume of the LUBF used as the model's volume constraint.

3. To measure the success of the model, we compared total usage to total on-hand quantities of both the LUBF and the model recommended stockage levels. This assumes that there are no reorder points and that the on-hand stocks are not automatically replenished during the deployment due to reaching reorder points vice actual usage.

In practice, the MEU does establish reorder points and on-hand stocks are automatically replenished throughout the deployment. The MEU stocks its initial on-hand quantities based on a projected 30-day usage, and sets requisitioning objectives and reorder points based on a percentage of that stock level. The initial stocks may vary based on the MEUs known schedule of operations. For example, if the MSSG Supply Officer knows that the MEU will be doing a large operation during the early part of the

deployment, he may stock more batteries than the 30-day usage recommends. This is because he knows a large number of batteries will be used on the exercise, without time for replenishment to take effect.

The model and the LUBF initial quantities are both based on a 30-day projected demand. Our assumption of no replenishment and consequent measurement of success will overstate backorders for both the LUBF and the model stockage levels. Both would be receiving replenishments that would reduce the number of backorders over the course of the deployment. Therefore, we do not believe it will have an impact favoring either the model or the current method.

4. Personnel from the SMU Operations sections of both I MEF and II MEF stated that when the GenPak recommends MEU stockage levels for an item that supports numerous types of end items, it multiplies the expected demand for that item by the number of types of end items the part supports. For example, if the GenPak encounters a tire that has an expected MEU monthly usage of 10, but that tire is used on three types of end items that the MEU is taking on deployment, it will recommend a MEU stockage quantity of 30.

As discussed previously, the expected usage of 10 was initially based on the total usage of that tire, and did not break its usage down by individual end item types. Therefore, the *total* expected usage is actually 10 across all types of end items that part supports. The GenPak's multiplication of this usage overstates the demand for parts that support multiple items.

The I MEF and II MEF GenPaks calculate expected MEU usage quantities for the parts that support multiple types of end items in a similar manner, but they are presented differently on the report. The I MEF GenPak program multiplies the demand by the number of types of end items internally, and the report lists each part once with that adjusted usage quantity [Ref. 11]. The II MEF GenPak lists the part separately for each end item that part supports, and it is up to the personnel using the report to add the expected MEU usage quantities for that part to determine its total stockage [Ref. 12]. The personnel at both SMUs are aware of this problem with the GenPak output, but do not currently have a solution for it [Refs. 11,12].

We use the GenPak's method of calculating expected MEU demand because there is not currently a way in the supply system to break down usage into quantities per type of end item. Therefore, the overstated demand for the parts that support multiple end items will cause the model to stock more of those items than it would otherwise.

However, the model is still working with the same data that is available to the MSSG Supply Officer when he builds the supply block. Therefore, we do not believe this assumption affects the outcome of the test.

V. MODEL OUTPUT

A. GENERAL OBSERVATIONS

We ran the model on four sets of data: 26th MEU GenPak data, 11th MEU GenPak data, 11th MEU GenPak data from Laforteza's thesis, and 26th MEU using the past MEU usage database.

The model stocked a large percentage of its available NSNs each time it was run, concentrating more on breadth of NSN (taking a larger number of total NSNs) vice depth (taking larger quantities of each NSN, but fewer NSNs). As expected, it was inclined to stock fewer large-volume items, and often did not stock any of the items that were inordinately large.

We gave the model a volume constraint based on the volume of the CEC 5 and 6 items on the unit's deploying LUBF. We considered only CEC 5 and 6 items for these tests to limit the number of NSNs, with the exception of the retest of Laforteza's data that contained all CECs.

Success of the model stockage levels and the LUBF quantities was measured by comparing total backorders for each of the methods. A backorder was calculated by comparing the number total demands for an item to the number stocked. For example, if there were ten demands for a filter and the model stocked two, eight backorders would result. When the LUBF or the model quantity was greater than the quantity actually used, the backorders would be zero. There was no penalty for overstocked items.

This measurement of success is not completely accurate, because the data we had did not include the timing of the demands. The LUBF may have had replenishment of its stock and had sufficient quantities to cover the usage. However, backorder comparison is the most logical measure of success for the data we had and does provide a measurement common to both the model and the LUBF stockage levels.

The VMETRIC model was very simple to use. It was run using a 133 MHz Pentium laptop computer and the run time was between fifteen minutes and eight hours, depending on the number of NSNs the computer was processing. We used a MS-DOS version of the program, and files were converted from a Microsoft Excel spreadsheet into a comma-separated file for import into the program.

B. 26TH MEU RESULTS

The total volume on the 26th MEU LUBF was 15,201 cubic feet, of which 14,386 was for CEC 5 and 6 items. 943 of the 2,172 total NSNs were CEC 5 and 6. The GenPak listed 1,065 NSNs having II MEF usage, which we used as the model's input from which to choose the final stockage quantities. The demand rate was the sum of the GenPak's recommended quantity for each NSN, multiplied by 1,488 to represent approximately one million hours of usage. For example, if a specific NSN was listed six times with a recommended quantity of one for each time, the demand for that NSN was six multiplied by 1488, or 8,928.

The model stocked 897 of the 1,065 NSNs it was given to choose from, and used a total volume of 13,442 cubic feet. However, the model's summary report showed that the model was actually using all 14,386 cubic feet within its constraint. We were unable to resolve these volume differences in the program at the time this thesis was completed. Figure 3 summarizes the results of the test for the 26th MEU. It shows that the model performed significantly better than the MEU's LUBF despite using a smaller volume. The model resulted in a total of 52,596 backorders while the LUBF resulted in 68,416 backorders. This data suggests that the MEU could have reduced its backorders by 23% if it had used an availability based sparing model to stock its block. Additionally, as discussed in Chapter IV, the percentage reduction may be understated due to the unusually high usage data we received from II MEF.

26 MEU RESULTS	MEU LUBF	MODEL RESULT
Total Volume (CEC 5/6)	14386 ft^3	13442 ft^3
Number of NSNs stocked	943	897
Total Backorders	68416	52956

Figure 3.

We ran the model a second time using the usage data from six past MEUs. This data represented the CEC 5 and 6 items that had an average MEU usage of over four hits during a 13-month period. Although the MEU only uses the supply block during the six month deployment, this data was collected from the usage of all MEU components during the pre-deployment training. The list included 751 NSNs. The model stocked 749 of the 751 items available to it, and used a total volume of 14,415 cubic feet (working with a

constraint of 14,386 cubic feet). Despite the smaller number of NSNs stocked by the model, it still performed better than the LUBF, with 63,695 total backorders compared to 68,416 for the LUBF. This 7% reduction in backorders is also understated due to the unusually high usage data we received from II MEF. The improvements may have been even more significant if the past MEU usage data had included NSNs with one or more hits, vice just those with four or more hits. This would have allowed the model to stock more NSNs and most likely meet more of the usage demands.

C. 11TH MEU RESULTS

The total volume on the 11th MEU LUBF was 14,164 cubic feet, of which 13,320 was for CEC 5 and 6 items. 2,408 of the 4,483 total NSNs were CEC 5 and 6. The GenPak listed 5,684 NSNs having I MEF usage, which we used as the model's input from which to choose the final stockage quantities. The demand rate was the GenPak's recommended quantity for each NSN multiplied by 1,488 to represent the demand per one million operating hours. The model stocked 5,067 of the available 5,683 NSNs. However, it only used 11,661 cubic feet of its constraint of 13,320. Once again, the model performed better than the MSSG LUBF in the total number of backorders when compared to the actual 11th MEU usage. In this case, the LUBF quantities resulted in 15,090 backorders, while the model recommended stockage levels had just 6,992. The model could have reduced backorders by over 50%. However, as mentioned previously, the LUBF used for this comparison does not represent the actual on-hand quantities that the 11th MEU had with them when they deployed. We expect that the number of backorders for the LUBF quantities would have been reduced if we had been able to obtain an accurate pre-deployment LUBF. Therefore, we make only the very weak conclusion that the LUBF was not better than the model when given a large handicap.

D. A TEST USING LAFORTEZA'S DATA

We conducted a retest of the data presented in Laforteza's work. While the model used for this work is a similar concept to the one developed by Laforteza, there is a slight difference in the input parameters. For example, Laforteza used an essentiality factor in his test, which we chose not to do. He also tested his model using all CECs rather than just the CEC 5 and 6 NSNs with which we had previously been working. We retested Laforteza's data to determine whether these differences would affect the results.

Laforteza's work centered around the 11th MEU from I MEF, but used data from the deployment prior to the one we have already studied. The LUBF used 15,370 cubic feet of space, and the GenPak provided 19,100 NSNs from which to choose stockage levels. Laforteza calculated a monthly demand rate that we used in the model as demand, but we multiplied it by 1,488 to represent demand per one million operating hours.

Our model run stocked 18,609 items of a possible 19,100 provided by the GenPak, and slightly overshot its volume constraint by using 15,374 cubic feet. The demand for the 11th MEU was comprised of 1,100 NSNs. The 11th MEU LUBF quantities would have resulted in 4,730 backorders, while the VMETRIC model results had 1,090 backorders, a reduction of 3,640. Laforteza stated that his model could have reduced backorders by 13% [Ref. 3]. Our results show even greater reductions, with over a 75% reduction in backorders. Although both models resulted in improvements over the current method of building the block, we were unable to reconcile the large differences between them.

E. MODEL DEMONSTRATION AT THE 13TH MEU

Another aspect of the validity of an availability based sparing model is its ease of use from the user's point of view. In order to evaluate the model's applicability to the block-building process, we took a copy of the VMETRIC program to Camp Pendleton, CA, for a demonstration with the Supply Officer of MSSG-13, which was soon to deploy. The MSSG-13 had recently completed the block-building process.

Data was gathered from the 13th MEU in order to make the demonstration more relevant to them. We obtained a GenPak designed from the 13 MEU's equipment list and a newly-completed LUBF for use in calculating the total volume available for stocking. We ran the model for the MSSG, and allowed the Supply Officer to adjust the initial stock levels to meet her needs. Adjustment of the initial stock levels in VMETRIC is the equivalent of setting minimum levels for the model to stock.

1. MSSG Needs and Constraints in Using the Model

The current system for building the supply block does not leave the Supply Officer much confidence in the NSNs and quantities chosen for the LUBF. The Supply Officer is often forced to take the recommendations of the maintenance personnel because the GenPak is insufficient to meet his needs. However, the MSSG 13 Supply

Officer commented that maintenance personnel "ask for the world and see what they can get [Ref. 26]." Although the 13^{th} MEU was scheduled to deploy in less than two weeks at the time of the demonstration, the Supply Officer seemed still to be looking at our model output for answers as to what quantities should have been stocked. We believe that this is due to the lack of quality data she is provided to assist her in building her supply block, as well as the subjective manner in which the block is developed.

One requirement stated by the Supply Officer was that the model must provide output that is easy for the supply and maintenance personnel to understand [Ref. 26]. She stated that Maintenance personnel often toss the GenPak to the side because they do not understand the headings on the columns and do not generally trust reports coming from computers. This is not surprising because, as previously discussed, the GenPak does not include many mission essential items if they are not categorized with the proper CEC code. The GenPak also misses parts that are not given an association to a particular end item.

Additionally, the Supply Officer stated that computer support at many of the maintenance centers is limited. When asked to submit a "wish list" to MSSG Supply with regards to required repair parts, one maintenance shop hand wrote the list, put it in an envelope, and mailed it to the MSSG! Although e-mail exists at most of the maintenance locations, many units are reluctant to use available computer technology.

A second requirement is that the model be easy to manipulate from a PC screen. The Supply Officer envisioned calling a representative from each maintenance detachment into her shop, where she could have the model set up on her PC. The maintenance detachment would give recommendations regarding minimum and maximum quantities desired for certain NSNs, and recommendations for NSNs to be added or deleted from the master item list.

While a volume constraint is something that the MSSG does not currently consider, the MSSG Supply Officer agreed that the model's capability to fill to a volume constraint would be useful. The model would give the MSSG the opportunity to experiment with different volume levels and different minimum and maximum stocks for certain NSNs. Additionally, if the space for the supply block were suddenly decreased, the model could be used to quickly modify stockage quantities.

2. MSSG Impressions of Model

The MSSG Supply Officer was impressed with the ease of use of the model, and its ability to be easily adapted for minimum and maximum stock levels. It was difficult for her to analyze the model's recommended stockage levels or compare the model's output to her own LUBF, because the model did not stock many of the items listed on the current MSSG-13 LUBF. The model's input data had been a CEC 5 and 6 GenPak created from the 13th MEU EDL. However, there were many items not included on the GenPak that the MSSG maintenance personnel had requested be stocked. As previously discussed, the GenPak does not have an association to an end item for many of the resident repair parts, so they are not listed as needing to be stocked. Also, the maintenance personnel request many items that are not CEC 5 and 6, yet are still critical repair parts to the end item.

This is the biggest barrier to implementation of the model for creating the supply block. We are running the model using the same poor data that the GenPak currently provides to the Supply Officer. The model can only stock the items that the GenPak includes, and we have already noted that those items are significantly lacking due to inaccurate CEC codes and faulty association data between parts and end items.

Another reason for the differences in stockage levels was the model's input for demand at the time of the demonstration. We mistakenly used the recommended stockage levels given for each NSN by the GenPak, rather than multiplying that number by 1,488 to better represent demands per one million operating hours. We had not yet realized that this conversion was necessary for the proper running of the model. For this reason, the stockage levels recommended by the model were much lower than the results discussed earlier in the chapter and will most likely not perform as well as they would have with the revised demand figures.

We attempted to change some of the initial stock levels (representing minimum stockage quantities) on certain items that we expected to have high MEU usage. However, the model results still looked significantly different than what the MEU had already decided to take. We cannot know how effective either the model or the MSSG's current supply block is until their deployment is completed.

F. SUMMARY

1. Numerical Results of the Model Tests

Figure 4 summarizes the results of the model tests. In every case, the block produced with an availability based model performed better than the supply block produced by the current system. This was despite the lack of user interaction with the model, which could improve the model's stockage quantities for items where MEU demand differs significantly from MEF demand.

UNIT	MODEL B/O	LUBF B/O	% IMPROVEMENT
26th MEU	52596	68416	23%*
26th MEU (past MEU data)	63695	68416	7%*
11th MEU	6992	15090	54%**
11th MEU (Laforteza's data)	1090	4730	77%

*Understated due to suspected incorrect usage data.
**Overstated due to an incomplete LUBF.

Figure 4. Summary of Model Results

The model results based on the past-MEU usage data did not perform as well as those based on the GenPak. However, we cannot make a conclusion regarding their relative utility in stocking the block because the past-MEU usage data limited the number of NSNs considered by the model. It only included NSNs with usage quantities of four or greater, while the GenPak includes any NSN with greater than one hit in the MEF for an entire year.

2. Problems Encountered With Input Data

The data provided as the input to the model was significantly lacking in the areas of completeness and relevance. The GenPak provides the "master list" of NSNs to be considered for stockage in the supply block. However, that list is incomplete for two major reasons. The first is the inaccuracy of CEC codes. When a Supply Officer asks for CEC 5 and 6, he is looking for repair parts critical to the availability of an end item. According to supply and maintenance personnel, there are many parts that are not CEC 5 and 6 that can render an end item inoperable, and they routinely include these items for

stocking in the supply block. The second problem is that of poor association data between end items and repair parts. There are repair parts that exist that have no association to an end item. Therefore, the GenPak will not include the repair part when it produces a usage list for that end item. Once again, the experience of the supply and maintenance personnel is necessary to compile a complete list of parts to be considered for stockage.

We found the complete MEU usage data difficult to compile. Although maintenance and supply records should match because the systems interface with one another, the results are significantly different. The 11th MEU usage data we received from the supply and maintenance systems attest to this fact. The two systems had a difference of 1,611 NSNs used for the deployment time. Another difficulty faced in gathering MEU usage data is that the supply system does not maintain separate usage data for a MEU. The compilation of the three MEU components must be done by hand and then consolidated, and the data must be limited to the deployment time. In the case of the usage data we received for the 26th MEU, those compilations did not appear to be done accurately.

Finally, the failure of the MSSGs to keep their initial deployment LUBFs made backtesting of the model difficult. The absence of an accurate LUBF for the 11th MEU made the results of that test inconclusive, because we simply do not know how well the true 11th MEU LUBF would have performed.

3. Using the Model in Practice

We do not expect that this model will be used without any user interaction to build a parts block and send it on deployment. It has potential as a tool, to be used with the knowledge and expertise of the user, to build the most effective parts block within a given volume constraint.

One possible shortcoming of the model is its reluctance to stock larger-sized items. A part may be critical to the repair of an end item, yet the model may avoid stocking it due to its volume. Additionally, any backorders associated with these larger items will have proportionally larger transportation costs because of their size and weight.

We propose that the model would perform better if the user implemented it in the following way. First, the user runs the model with no user interaction as it was done for the tests in our work. Next, allow supply and maintenance personnel to examine the

model results, particularly looking at the quantities recommended by the model for the larger items. The user may then change the minimum and maximum stock levels for these items (or any other items that the model is stocking in unacceptably high or low quantities), forcing the model to operate within the constraints given to it by the user. They would then run the model again, with the model then building a block using the remaining available volume (minus the volume of the minimum stock levels) and maximizing the items within that new volume. The user would continue with this cycle until a block is built that meets his requirements. This methodology allows the user to overcome the model's tendency to stock fewer large-volume items.

VI. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

A. SUMMARY

The goal of the Marine Corps MEU(SOC) is to be ready to conduct any of its 29 missions within a moment's notice. Readiness is the key to the MEU(SOC)'s success.

We introduced the MEU(SOC) structure and the MSSG's mission to provide supply support to the other elements of the MEU. We discussed an availability based sparing model developed in a past work, showing its positive results in assisting the MSSG with the building of its supply block. However, we argued that the model had not been sufficiently tested, as its results were based on the data from only one MEU deployment. The requirement for more testing across several MEUs was necessary to prove or disprove the validity of the results.

We also examined the current procedures for building the MSSG supply block (consumable repair parts) at units of I MEF, II MEF, and III MEF. The procedures themselves are not significantly different across the Marine Corps, but there are differences in the format and content of the GenPak, the primary report provided to Supply Officers in building their supply block. However, all Supply Officers we interviewed agreed that they used the GenPak very little and depended primarily on the experience of their maintenance detachment personnel for input regarding what items should be stocked for deployment.

We discussed the idea of mission priority factors that could be assigned to end items and transferred down to their corresponding repair parts. We considered two types of priority factors, the first being a general priority across missions and the second prioritizing end items for each specific MEU(SOC) mission. While the first method is plausible, its implementation had very little effect on the model output. We did not implement the second method because we did not receive strong support for the idea in the interviews we conducted, and a look at the execution of some of the MEU(SOC) missions shows that a single mission can be executed in very different ways depending on outside factors.

We introduced the data used to further validate the availability based sparing model, along with shortfalls in the data. The major shortfalls included the lack of retention of MSSG initial deployment stockage levels, the inaccuracy of CEC codes, the

inability of the supply system to associate all repair parts with an end item, and the inaccuracies in complete MEU usage data. Despite these data shortfalls, we showed the results of three tests of the model, with all of the model results performing better than the supply blocks taken with the MEUs. Running the model also proved to be much less time-consuming than current procedures, with a single run taking anywhere from fifteen minutes to six hours. A methodology for effectively using an availability based sparing model was proposed. Finally, the model was demonstrated for a unit preparing to deploy. The MSSG Supply Officer expressed interest in using the model, which would provide a quick way to explore alternative supply blocks and to revise volume constraints as necessary.

B. CONCLUSIONS

1. Usefulness of GenPak Data to MSSGs

The usefulness of the data contained in the GenPak could be greatly improved through the validation of CEC codes and better association of repair parts to specific end items. All interviews we conducted with MSSG Supply Officers showed that the supply and maintenance personnel do not use the GenPak as a primary source of data when building their supply blocks because the items included on the GenPak are incomplete. Most of the parts and quantities are determined by the experience of the maintenance personnel.

The GenPak data could be improved by taking into account the smaller number of MEU end items as compared to the number of MEF end items. The current data sources require consolidation of several different reports in order to obtain a percentage of MEU end items to the total MEF quantity. If supply and maintenance personnel have that ratio of MEU to MEF end item quantities, they can better calculate an accurate demand for parts associated with that particular end item.

2. Effectiveness of the Model in Stocking the MSSG Supply Block

Our results suggest that an availability based sparing model is an effective tool to help the MSSG personnel. Without any user interaction, the model outperformed the current method building the supply block. User interaction could improve the model's performance for items with unusual high or low MEU usage as compared to that of the

MEF. The model is also a quick, easy tool for the Supply Officer to use in cases when the space available for the supply block changes. It allows for easy manipulation of minimum and maximum quantities, and the proposed methodology for its use can provide a way for the Supply Officer to compare several different possible block configurations prior to deployment.

However, it should be noted that the quality of the model output is only as good as the input data. With the data available to us during this study, it did not perform as well as it may if the input data is improved.

3. Use of Mission Priority Factors in Stocking the Supply Block

We chose not to use mission priority factors in stocking the supply block. The overall mission priority factors Laforteza gave to end items had no significant impact on his model results. The variability in missions, even missions of the same type, makes it difficult to give a type of end item a priority for a certain mission. Additionally, the ability of a MEU to know any detail about the type, location, and scope of missions it will conduct is limited. The purpose of the MEU is to be ready to conduct all missions, and it cannot afford to degrade that capability by planning for only a limited number of them.

C. RECOMMENDATIONS

1. The Deployment Support Unit and MSSG Supply Officers should keep LUBFs from the beginning of deployments to facilitate further testing of models to improve the quality of the supply block, and for use by new Supply Officers in building their supply blocks.

2. A review of the CEC system should be conducted to validate the current CEC codes and improve the quality of GenPak data.

3. A review of end items and their associated repair parts should be initiated that will eliminate repair parts that have no association to an end item.

4. Continued efforts should be made create a GenPak that accounts for the percentage of MEU end items to the quantity throughout the entire MEF and adjusts recommended MEU stockage quantities based on that percentage.

5. Complete MEU usage data should be kept by the Deployment Support Unit and SMU Operations Sections with a database that encompasses all units of the MEU

vice just the MSSG. Further research should be done when sufficient MEU data exists that compares the validity of past MEU data to that of MEF data when estimating demand for an outgoing MEU.

6. A comprehensive effort should be made across the Marine Corps to resolve discrepancies between the usage data maintained by the supply system and that held by the maintenance system. These systems should be reconciled to provide a clear picture to the individuals needing to use this data.

7. The proposed methodology for using an availability based sparing model should be implemented, with the model provided as a tool for the MSSG Supply Officer to use in building the supply blocks.

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26. Personal communication between Capt Harrington (MSSG 13 Supply Officer) and the author, 24 November 1998.

APPENDIX A. COMBAT ESSENTIALITY CODE

CEC	Definition
1	Combat Essential End Item. End items of equipment whose availability in a combat ready condition is essential for execution of the combat and training mission of the command.
2	Non-Critical Repair Part. Repair parts whose failure in the end item will not render it inoperative or reduce its effectiveness below the minimum acceptable level of efficiency, and which do not fit the definition of code 3 or 4 items.
3	Critical Item/Repair Part for Health and Safety of Personnel. Those items that are required for the health and safety of personnel, and which do not fit the definition of code 5 or 6 items.
4	Critical Item/Repair Part for State and Local Laws. Those items that are required to conform with state and local laws, and which do not fit the definition of code 5 or 6 items.
5	Critical Repair Part to a Combat Essential End Item. Repair parts whose failure in a combat essential end item will render it inoperative or reduce its effectiveness below the minimum acceptable level of efficiency.
6	Critical Repair Part to a Non-Combat Essential End Item. Repair parts whose failure in a non-combat essential end item will render it inoperative or reduce its effectiveness below the minimum acceptable level of efficiency.

APPENDIX B. EXCERPTS FROM DEPLOYMENT SUPPORT GENERATOR PACKAGES/CAMP PENDLETON AND CAMP LEJEUNE

DATE: 10/13/1998
TIME: 08:39.49

REPORT 1 OF 5 FOR M20177
IDI ON DENSITY LIST (NOT IN BLOCK -- ADD QTY)
(IN 'HITS' SEQUENCE)

PROGRAM: DUGHPCK3 — 1818 · 09 Oct 98 — LIBRARY: DGJA&SMU

RECORD NSN	UI	CEC	NEW RO	GABF ONH	GABF HITS	GABF DMD QTY	GABF RO	GABF AMRD	UNIT ONH	UNIT DUE	UNIT HITS	UNIT PRICE	PART NOMENCLATURE	END-ITEM NOMENCLATURE
1005-01-252-3011	EA	5	1	4	10	10	4	1				76.92	PINTLE,MOUNT	LIGHT ARMORED VEHICLE ANTI-TAN
2520-00-919-7240	EA	5	1	11	10	11	4	1				.73	COVER	LIGHT ARMORED VEHICLE ANTI-TAN
2520-01-065-0070	EA	5	1	4	10	10	4	1				12.17	RETAINER,CLUTCH SPR	LIGHT ARMORED VEHICLE ANTI-TAN
2520-01-154-9968	EA	5	1	1	10	15	5	1				5.94	HOUSING DISC,HUB	LIGHT ARMORED VEHICLE ANTI-TAN
2530-01-168-9854	EA	5	2	6	10	28	8	2				116.49	TIE ROD END,STEERIN	LIGHT ARMORED VEHICLE ANTI-TAN
2540-01-162-0552	EA	5	1	11	10	17	12	1				193.41	VISION BLOCK,DIRECT	LIGHT ARMORED VEHICLE ANTI-TAN
2540-01-179-4387	SE	5	2	5	10	25	4	2				69.31	BELT,VEHICULAR SAFE	LIGHT ARMORED VEHICLE ANTI-TAN
2920-01-060-0956	EA	5	2	3	10	18	9	2				20.09	PARTS KIT,IGNITION	TRUCK UTILITY 1/4 TON 4X4
3030-00-832-5671	SE	5	2	27	10	18	8	2				4.42	BELTS,V,MATCHED SET	TRUCK UTILITY 1/4 TON 4X4
3040-01-106-7183	EA	5	1	4	10	10	4	1				856.40	HOUSING,MECHANICAL	LIGHT ARMORED VEHICLE ANTI-TAN
3120-00-678-1824	EA	5	1	6	10	12	4	1				24.08	BEARING HALF SET,SL	TRUCK UTILITY 1/4 TON 4X4
3120-01-285-8849	EA	5	2	6	10	27	7	2				6.03	BEARING,SLEEVE	LIGHT ARMORED VEHICLE ANTI-TAN
4130-00-574-1916	EA	5	2	2	10	20	4	2				12.14	FILTER-DRIER,REFRIG	AIR CONDITIONER
4130-01-048-5393	EA	5	1	4	10	15	7	1				424.95	COMPRESSOR UNIT,REF	AIR CONDITIONER
4210-00-796-8260	EA	5	1		10	15	1	1				16.27	HANDLE,FIRE EXTINGU	LIGHT ARMORED VEHICLE ANTI-TAN
4820-01-158-9223	EA	5	2	9	10	18	4	2				17.30	COCK,DRAIN	LIGHT ARMORED VEHICLE ANTI-TAN
4930-00-051-3194	EA	5	2	2	10	22	4	2				382.27	NOZZLE,FUEL AND OIL	FUEL SYS AMPHIBIOUS ASSAULT
5305-00-608-2111	HD	5	1	28	10	12	4	1				6.75	SCREW,CAP,HEXAGON H	FUEL SYSTEM AMPHIB ASSAULT(HC)
5305-00-727-2283	EA	5	3	51	10	39	26	3				.29	SCREW,CAP,HEXAGON H	FUEL SYS AMPHIBIOUS ASSAULT
5305-00-821-3869	HD	6	1	10	10	15	14	1				8.94	SCREW,CAP,HEXAGON H	TRUCK UTILITY 1/4 TON 4X4
5305-00-889-3000	HD	5	1	6	10	11	5	1				.63	SCREW,MACHINE	TRUCK UTILITY 1/4 TON 4X4
5305-01-178-7325	EA	5	2	22	10	26	15	2				.01	SCREW,MACHINE	LIGHT ARMORED VEHICLE ANTI-TAN
5305-01-184-1937	EA	5	3	1	10	31	8	3				.13	SCREW,CAP,HEXAGON H	LIGHT ARMORED VEHICLE ANTI-TAN
5306-00-610-8395	EA	5	7	41	10	85	41	7				13.70	BOLT,MACHINE	MACHINE GUN CALIBER .50 CAL, M
5306-21-907-8465	EA	5	2	8	10	22	8	2				12.07	BOLT,MACHINE	LIGHT ARMORED VEHICLE ANTI-TAN
5310-00-929-6395	HD	5	2	3	10	22	9	2				.65	WASHER,LOCK	LIGHT ARMORED VEHICLE ANTI-TAN
5310-00-975-2075	HD	5	1	2	10	10	6	1				3.20	NUT,PLAIN,HEXAGON	TRUCK UTILITY 1/4 TON 4X4
5310-01-155-5398	EA	5	1	4	10	14	4	1				.98	NUT,PLAIN,CAP	LIGHT ARMORED VEHICLE ANTI-TAN
5315-01-359-1451	EA	5	1	22	10	13	4	1				.01	PIN,COTTER	LIGHT ARMORED VEHICLE ANTI-TAN
5325-00-102-8843	EA	5	1		10	10	4	1				.91	RING,RETAINING	LIGHT ARMORED VEHICLE ANTI-TAN
5325-00-543-2902	EA	5	1	3	10	10	4	1				.11	GROMMET,NONMETALLIC	TRUCK UTILITY 1/4 TON 4X4
5325-01-157-1364	EA	5	2	8	10	29	14	2				.24	RING,RETAINING	LIGHT ARMORED VEHICLE ANTI-TAN
5330-00-792-9026	EA	5	5	77	10	58	56	5				3.02	GASKET	FUEL SYSTEM AMPHIB ASSAULT(HC)
5330-00-835-1706	EA	5	4	13	10	45	13	4				2.29	SEAL,PLAIN ENCASED	LIGHT ARMORED VEHICLE ANTI-TAN
5330-01-163-4810	EA	5	3	13	10	38	15	3				5.63	SEAL ASSEMBLY	LIGHT ARMORED VEHICLE ANTI-TAN
5330-01-163-4968	EA	5	2	11	10	23	11	2				11.12	SEAL,PLAIN	LIGHT ARMORED VEHICLE ANTI-TAN
5330-01-296-9906	EA	5	1	8	10	12	8	1				2.14	GASKET	LIGHT ARMORED VEHICLE ANTI-TAN
5331-01-167-1897	EA	5	1		10	16	5	1				.79	O-RING	LIGHT ARMORED VEHICLE ANTI-TAN
5342-01-160-0636	EA	5	4	26	10	49	29	4				21.70	SLIP LINK ASSEMBLY	LIGHT ARMORED VEHICLE ANTI-TAN
5342-01-164-3297	EA	5	1	3	10	14	4	1				8.46	CLAMP	LIGHT ARMORED VEHICLE ANTI-TAN
5365-21-880-8106	EA	5	3	.	10	36	15	3				.21	SHIM RING	LIGHT ARMORED VEHICLE ANTI-TAN
5930-00-876-1634	EA	5	1		10	11	4	1				47.44	SWITCH,THERMOSTATIC	AIR CONDITIONER
5930-01-095-9805	EA	5	4	16	10	44	16	4				14.53	SWITCH,THERMOSTATIC	LIGHT ARMORED VEHICLE ANTI-TAN
5930-01-141-5368	EA	6	2	8	10	27	8	2				2.74	BOOT,DUST AND MOIST	LIGHT ARMORED VEHICLE ANTI-TAN
5935-00-900-6281	EA	5	4	17	10	43	16	4				3.01	ADAPTER,CONNECTOR	TRUCK UTILITY 1/4 TON 4X4

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ID NUM	END ITEM NOMEN	NSN	RQMT CD	C E C	UI CD	NOMEN	GARF RO	GARF ONH	RTDMD HITS	RTDMD RD	DUE IN	GA RO	GA MSL	GARF AMRD	BUY QTY	UNIT PRICE	EXT PRICE
05538C	RIFLE,5.56MM	1005000179540	3LEC	5	EA	DETENT,PAW	32	35	49	234	0	0	0	5	1.	0.05	0.05
05538C	RIFLE,5.56MM	1005000179543	3LEC	5	EA	SWIVEL,SLI	188	2469	98	1171	0	0	0	47	5.	0.54	2.70
05538C	RIFLE,5.56MM	1005000179546	3LIC	5	AY	HANDLE ASS	92		106	358	101	1	0	23	2.	16.02	32.04
05538C	RIFLE,5.56MM	1005000179547	3LEC	5	EA	PIN,FIRING	144	139	139	747	0	0	0	51	5.	2.60	13.00
05538A	RIFLE 5.56MM W/	1005000179548	3LIC	5	EA	CATCH,BOLT	24	24	32	67	0	0	0	9	1.	4.62	4.62
05538B	RIFLE 5.56MM		3LIC	5	EA	CATCH,BOLT	24	24	32	67	0	0	0	9	1.	4.62	4.62
05538C	RIFLE,5.56MM		3LIC	5	EA	CATCH,BOLT	24	24	32	67	0	0	0	9	1.	4.62	4.62
05538C	RIFLE,5.56MM	1005000506357	3LEC	5	EA	ROD SECTIO	7200	5771	198	2624	0	0	0	1487	149.	0.27	40.23
08671A			3LEC	5	EA	ROD SECTIO	7200	5771	198	2624	0	0	0	1487	149.	0.27	40.23
05538B	RIFLE 5.56MM	1005000562247	3LIC	5	EA	PLUNGER,BO	56	134	9	28	0	0	0	14	1.	0.31	0.31
05538C	RIFLE,5.56MM		3LIC	5	EA	PLUNGER,BO	56	134	9	28	0	0	0	14	1.	0.31	0.31
08087A		1005000726112	3LEC	5	EA	SUPPORT,DE	4	4	26	29	0	0	0	7	1.	21.23	21.23
05539B	RIFLE,SNIPER W/	1005002883565	3LIC	5	PG	SWAB,SMALL	24	40	56	481	0	0	0	6	1.	10.78	10.78
08993A			3LIC	5	PG	SWAB,SMALL	24	40	56	481	0	0	0	6	1.	10.78	10.78
09629A			3LIC	5	PG	SWAB,SMALL	24	40	56	481	0	0	0	6	1.	10.78	10.78
09724A			3LIC	5	PG	SWAB,SMALL	24	40	56	481	0	0	0	6	1.	10.78	10.78
02705E		1005003127177	3LEC	5	EA	SLING,SMAL	160	108	110	549	0	0	0	42	4.	5.82	23.28
08206A			3LEC	5	EA	SLING,SMAL	160	108	110	549	0	0	0	42	4.	5.82	23.28
08671A			3LEC	5	EA	SLING,SMAL	160	108	110	549	0	0	0	42	4.	5.82	23.28
08673A	LAUNCHER,ASSAUL		3LEC	5	EA	SLING,SMAL	160	108	110	549	0	0	0	42	4.	5.82	23.28
09001A			3LEC	5	EA	SLING,SMAL	160	108	110	549	0	0	0	42	4.	5.82	23.28
02705B	MACHINE GUN 7.6	1005003504100	3LEC	5	EA	BRUSH,CLEA	88	82	40	163	0	0	0	22	2.	1.72	3.44
02705C	MACHINE GUN	1005003504100	3LEC	5	EA	BRUSH,CLEA	88	82	40	163	0	0	0	22	2.	1.72	3.44
02705E			3LEC	5	EA	BRUSH,CLEA	88	82	40	163	0	0	0	22	2.	1.72	3.44
06510A	MOUNT TRIPOD MA		3LEC	5	EA	BRUSH,CLEA	88	82	40	163	0	0	0	22	2.	1.72	3.44
08670A			3LEC	5	EA	BRUSH,CLEA	88	82	40	163	0	0	0	22	2.	1.72	3.44
08673A	LAUNCHER,ASSAUL		3LEC	5	EA	BRUSH,CLEA	88	82	40	163	0	0	0	22	2.	1.72	3.44
09111A			3LEC	5	EA	BRUSH,CLEA	88	82	40	163	0	0	0	22	2.	1.72	3.44
00591A	TELESCOPE OBSER	1005004035804	3LEC	5	EA	CASE,SMALL	1200	773	127	7860	0	0	0	819	82.	0.74	60.68
05538C	RIFLE,5.56MM		3LEC	5	EA	CASE,SMALL	1200	773	127	7860	0	0	0	819	82.	0.74	60.68
08993A			3LEC	5	EA	CASE,SMALL	1200	773	127	7860	0	0	0	819	82.	0.74	60.68
05538C	RIFLE,5.56MM	1005004061570	3LEC	5	EA	KIT,ADAPTO	68	176	12	118	0	0	0	49	5.	1.95	9.75
07700A			3LEC	5	EA	KIT,ADAPTO	68	176	12	118	0	0	0	49	5.	1.95	9.75
02498B		1005004874100	3LEC	5	EA	COVER,GUN	12	7	15	48	0	0	0	5	1.	52.92	52.92
02498C	MACHINE GUN, .5		3LEC	5	EA	COVER,GUN	12	7	15	48	0	0	0	5	1.	52.92	52.92
10004A			3LEC	5	EA	COVER,GUN	12	7	15	48	0	0	0	5	1.	52.92	52.92
05538C	RIFLE,5.56MM	1005004946602	3LEC	5	EA	BRUSH,CLEA	5200	5126	250	3636	24	0	0	1341	134.	0.51	68.34
05539B	RIFLE,SNIPER W/		3LEC	5	EA	BRUSH,CLEA	5200	5126	250	3636	24	0	0	1341	134.	0.51	68.34
06510A	MOUNT TRIPOD MA		3LEC	5	EA	BRUSH,CLEA	5200	5126	250	3636	24	0	0	1341	134.	0.51	68.34
08521A			3LEC	5	EA	BRUSH,CLEA	5200	5126	250	3636	24	0	0	1341	134.	0.51	68.34
08671A			3LEC	5	EA	BRUSH,CLEA	5200	5126	250	3636	24	0	0	1341	134.	0.51	68.34
08673A	LAUNCHER,ASSAUL		3LEC	5	EA	BRUSH,CLEA	5200	5126	250	3636	24	0	0	1341	134.	0.51	68.34
08993A			3LEC	5	EA	BRUSH,CLEA	5200	5126	250	3636	24	0	0	1341	134.	0.51	68.34
09629A			3LEC	5	EA	BRUSH,CLEA	5200	5126	250	3636	24	0	0	1341	134.	0.51	68.34
09724A			3LEC	5	EA	BRUSH,CLEA	5200	5126	250	3636	24	0	0	1341	134.	0.51	68.34
10004A			3LEC	5	EA	BRUSH,CLEA	5200	5126	250	3636	24	0	0	1341	134.	0.51	68.34
02498B		1005005559332	3LIC	5	EA	PINTLE,MOU	5	5	10	24	0	0	0	5	1.	40.70	40.70
02498C	MACHINE GUN, .5	1005005559332	3LIC	5	EA	PINTLE,MOU	5	5	10	24	0	0	0	5	1.	40.70	40.70
10004A			3LIC	5	EA	PINTLE,MOU	5	5	10	24	0	0	0	5	1.	40.70	40.70
02498A		1005005564102	3LEC	5	EA	ROD,CLEANI	600	576	73	1870	0	0	0	307	31.	0.98	30.38
02498B			3LEC	5	EA	ROD,CLEANI	600	576	73	1870	0	0	0	307	31.	0.98	30.38
02498C	MACHINE GUN, .5		3LEC	5	EA	ROD,CLEANI	600	576	73	1870	0	0	0	307	31.	0.98	30.38

APPENDIX C. MEU(SOC) MISSIONS

- AMPHIBIOUS ASSAULT
- AMPHIBIOUS RAID
- AMPHIBIOUS DEMONSTRATION
- AMPHIBIOUS WITHDRAWAL
- IN-EXTREMIS HOSTAGE RECOVERY (IHR)
- SEIZURE/RECOVERY OF OFFSHORE ENERGY FACILITIES
- VISIT, BOARD, SEARCH AND SEIZURE OPERATIONS (VBSS)
- SPECIALIZED DEMOLITION OPERATIONS
- TACTICAL RECOVERY OF AIRCRAFT AND PERSONNEL (TRAP)
- SEIZURE/RECOVERY OF SELECTED PERSONNEL OR MATERIAL
- COUNTERPROLIFERATION (CP) OF WEAPONS OF MASS DESTRUCTION
- PEACE OPERATIONS
- SECURITY OPERATIONS
- NON-COMBATANT EVACUATION OPERATIONS (NEO)
- REINFORCEMENT OPERATIONS
- JOINT/COMBINED TRAINING/INSTRUCTION TEAM
- HUMANITARIAN ASSISTANCE/DISASTER RELIEF
- TACTICAL DECEPTION OPERATIONS
- FIRE SUPPORT PLANNING, COORDINATION, AND CONTROL IN A JOINT/COMBINED ENVIRONMENT
- SIGNAL INTELLIGENCE (SIGINT)/ELECTRONIC WARFARE (EW)
- MILITARY OPERATIONS IN URBAN TERRAIN (MOUT)
- RECONNAISSANCE AND SURVEILLANCE (R&S)
- INITIAL TERMINAL GUIDANCE (ITG)
- COUNTERINTELLIGENCE OPERATIONS (CI)
- AIRFIELD/PORT SEIZURE
- LIMITED EXPEDITIONARY AIRFIELD OPERATIONS
- SHOW OF FORCE OPERATIONS
- JTF ENABLING OPERATIONS
- SNIPING OPERATIONS

APPENDIX D. INPUT REQUIREMENTS FOR THE VMETRIC MODEL

INPUT	**REQUIRED**
Part Name	
Reference Number	X
Quantity Per Assembly (QPA)	X
Item Price	X (unless using shadow price)
MRR6 (Demands/million operating hours)	X
MTDs (Maintenance Task Dist'n, Site)	
MDTi (Maintenance Task Dist'n, Intermed)	
MDTd (Maintenance Task Dist'n, Depot)	
RCTs (Repair Cycle Time, Site)	
RCTi (Repair Cycle Time, Intermediate)	
RCTd (Repair Cycle Time, Depot)	
PLT (Procurement Lead Time)	
ADTP (Admin and Delay Lead Time)	
MTBF (Mean Time Between Failures)	Can be used instead of MRR6
DC (Duty Cycle)	
RIP (Repair in Place rate)	
NFF (No Fault Found Rate)	
ISs (Initial Stock, Site)	
ISi (Initial Stock, Intermediate)	
ISd (Initial Stock, Depot)	
MAXS (Maximum Stock Level)	
MSs (Maximum Stock, Site)	
Msi (Maximum Stock, Intermediate)	
MSd (Maximum Stock, Depot)	
Volume	
Weight	
Criticality	
Shadow Price	

INPUT	REQUIRED
Item VMAX (Variance to Mean Ratio)	
Cannibalization Allowed (Y/N)	Defaults to Cannibalization Allowed
PCCN (Provisioning Contract Control Number)	
PLISN (Provisioning Line Item Sequence Number)	
CAGE (Commercial and Government Entity Code)	
NSN (National Stock Number)	
SMR (Source, Maintainability and Recovery Code)	X

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